363
AUG 2 2 1987
83-B-4 A13.79:PNW-RN-461

United States Department of Agriculture
Forest Service
Pacific Northwest Research Station
Research Note PNW-RN-461

Bud Characteristics of Unrooted Stem Cuttings Affect Establishment Success of Cottonwood

M.A. Radwan, J.M. Kraft, and D.S. DeBell

Abstract

Experimental plantings of different genotypes of cottonwood were examined. The four clones tested were: a *Populus* hybrid (Dula, D-01), a *P. trichocarpa* x *P. deltoides* hybrid (Hybrid 11), and two native *P. trichocarpa* clones (Nisqually 1 and Orting 5). Establishment success and characteristics of hardwood cuttings or resulting plants that might be related to success were determined. Establishment success varied significantly ($P < 0.01$) among the four clones in the order, Orting = Dula > Hybrid 11 > Nisqually. Also, there was much variation among the clones in the relative proportion of internodal shoots, dead buds, and "spent" buds. Results suggest that best establishment and growth are achieved when cuttings have healthy axillary buds at planting. Establishment success from such cuttings would be fairly high, and resulting experimental plantings would permit valid comparisons of productivity of different genotypes of cottonwood.

Keywords: Stem cuttings, genotypes, black cottonwood, *Populus trichocarpa*.

Introduction

Stem cuttings of black cottonwood (*Populus trichocarpa* Torr. & Gray) root easily, and unrooted cuttings (or whips) have frequently been used to establish new plantations in the Pacific Northwest. As with other species, however, different sources of cottonwood can differ considerably in their ability to root, and this, in turn, can affect establishment success. An example of such variation has been reported among different clones of *P. trichocarpa* and hybrids of *P. trichocarpa* x *P. deltoides* (Heilman and Stettler 1985). Additional factors such as quality of cuttings used, soil conditions, and weather during and after planting can also influence development of both roots and shoots.

In 1985, we attempted to establish from cuttings an experimental plantation containing two *Populus* hybrid clones and two native *P. trichocarpa* clones near Yelm in western Washington. From the start, sprouting varied considerably among clones, and differences persisted through the growing season. Performance was particularly poor with two of the clones, and attempts to replace dead cuttings were not very successful. Variation in both establishment success and growth were clearly large enough to preclude fair assessment of biomass production of the different clones, which was the primary objective of the study.

Preliminary examination of a few cuttings and plants in midsummer 1985 suggested that the quality of cuttings may have been a factor in the variable performance of the different clones. This study, therefore, was conducted in late summer 1985 to test this hypothesis before another attempt at establishing the same clones was made in 1986.

M.A. RADWAN is principal plant physiologist, J.M. KRAFT is chemist, and D.S. DeBell is principal silviculturist, Forestry Sciences Laboratory, Pacific Northwest Research Station, 3625 93rd Avenue S.W., Olympia, Washington 98502.

COMPLETED
ORIGINAL

Methods

A total of four clones were studied as follows:

1. *Dula, D-01:* A *Populus* hybrid (taxonomic identity unknown) developed by the University of Idaho and Dula's Nursery of Canby, Oregon.
2. *Hybrid 11:* A *P. trichocarpa* x *P. deltoides* hybrid developed by the University of Washington and Washington State University.
3. *Nisqually 1:* A clone of *Populus trichocarpa.*
4. *Orting 5:* A clone of *Populus trichocarpa.*

The Dula cuttings were purchased from a private nursery, and cuttings of the other clones were provided by a forest products company. All cuttings were made in January and stored moist in plastic bags at 2-3 °C until planted.

Cuttings were planted in March 1985 at a fenced field, on State of Washington land, near Yelm. On the average, cuttings were about 30 cm long and were planted 20 cm deep; diameters varied by genotype and ranged from 5 to 30 mm. Before being planted plots were fertilized with a 16-16-16 commercial fertilizer at a rate of 100 kg each of nitrogen, phosphorus, and potassium per hectare. Plots also received a pre-emergent herbicide treatment (Goal + Kerb)[1] after planting. Overhead irrigation was begun in July 1985. There were three replications per treatment.

Establishment success was determined by examining 100 cuttings or resulting plants from each of three replications of the same spacing treatment per clone. Percentage success was calculated from the number of living plants and dead cuttings found. No distinction by amount or quality of growth was made among living plants.

Characteristics of cuttings or plants that might be related to establishment success were determined on 30 cuttings or plants from each of three replications of the same spacing treatment of each clone. The 30 cuttings or plants examined included 10 dead cuttings, 10 weak plants, and 10 vigorously growing plants, all selected at random within each category. Characteristics studied were "spent" and dead buds on cuttings, nodes above ground, live and dead shoots (normal and adventitious), and live roots. Spent buds were represented on the cuttings by old branch stubs; the original axillary buds had sprouted during the previous year, and resulting branches had been cut when cuttings were made from the stem. Dead buds were at the nodes; they were dark brown and clearly rotten. Normal shoots originated from the axillary buds present at the nodes at time of planting. Adventitious shoots were initiated in the internodes after planting.

---

[1] The use of brand names is for the convenience of the reader and does not constitute endorsement by the U.S. Department of Agriculture to the exclusion of other products that may be suitable.

Figure 1 shows an example of the three cutting and plant categories (that is, dead cuttings, weak plants, and vigorous plants) used in the study. Spent buds are contrasted with axillary buds in figure 2. All data were collected in late August 1985. Values for establishment success were treated by analysis of variance and means were separated by Tukey's test (Snedecor 1961).

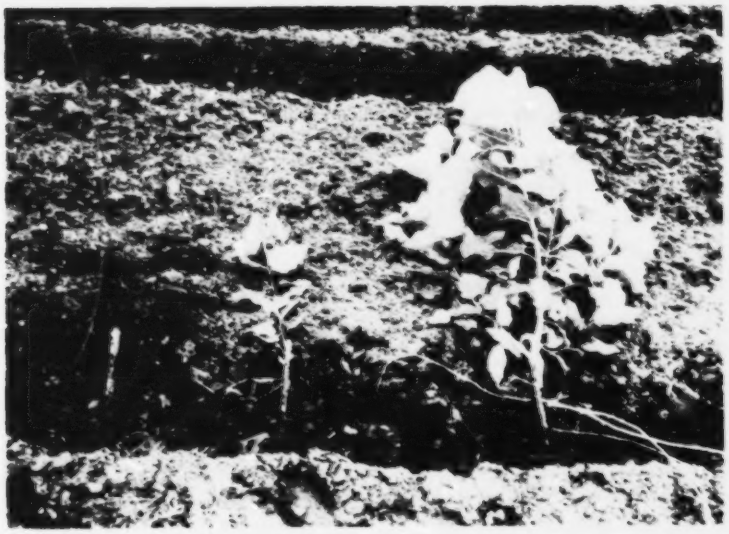

Figure 1—Example of the three cutting and plant categories studied. From left to right: dead cutting, weak plant, and vigorous plant.

Figure 2—Cuttings with healthy axillary buds (left) and spent buds (right).

BEST COPY AVAILABLE

Results and Discussion

Establishment success varied greatly between the four clones in the order, Orting = Dula > Hybrid 11 > Nisqually (table 1). Throughout the plantation, propagation by cuttings was obviously much more successful for Dula and Orting than for Hybrid 11 and Nisqually. This contrast is illustrated in figure 3, which shows the Orting and Nisqually clones in adjacent plots planted at the 1- by 1-m spacing.

Data in table 1 and figure 4 also show much variation among the clones in the characteristics of the cuttings or plants determined. Spent buds accounted for a greater percentage of total buds in the less successful clones (Hybrid 11 and Nisqually) than in the more successful ones (Dula and Orting). Also, within clones, spent buds were generally highest in dead cuttings, intermediate in weak plants, and lowest in vigorous plants. Unlike other clones, the Dula cuttings were prepared from plants grown in very dense ("wood grass") stool beds. This very high density limits light penetration and presumably discourages branching which, in turn, decreases the number of spent buds per cutting. Even at wider spacing, branching may vary by genotype. This is illustrated in figure 5 where Dula (minimal branching) and Hybrid 11 (much branching) plants from the same spacing treatment are shown.

Establishment success, therefore, seems to be correlated with the relative proportion of spent buds on the cuttings at planting which, in effect, reflects the lack of axillary buds.

Table 1—Selected characteristics of black cottonwood clones[1]

Item	Clone			
	Dula	Hybrid 11	Nisqually	Orting
Establishment success (percent of total cuttings)	76a	54b	34c	88a
"Spent" buds on cuttings (percent of total buds)	9	84	80	57
Dead buds on cuttings (percent of total buds)	55	2	6	19
Live nodal shoots per plant (percent of all shoots)	83	72	69	90
Live internodal shoots per plant (percent of all shoots)	0	28	31	8
Dead shoots (percent of all shoots)	17	0	0	2
Number of live shoots per plant	1.8	1.5	2.5	2.1

[1] Values are averages of 3 replications. Establishment success is based on 100 cuttings or plants from each of 3 replications per clone. Other items are based on 30 cuttings or plants from each of 3 replications per clone. Means in a horizontal sequence followed by different letter are statistically different at $p < 0.01$ by Tukey's test (Snedecor 1961).

Axillary buds burst early in the spring and produce the normal shoots. When these buds are absent, as when only spent and dead buds are present, establishment success depends on adventitious or suppressed buds. Initiation or development of these buds or both require much energy and time, and that would at least delay shoot development and growth. Our survey showed that vigorous shoots were formed consistently at the nodes from axillary buds, whereas weak shoots almost always resulted from adventitious buds in the internodes below the ground surface. This may not hold true for different genetic stock or environmental conditions. For example, a

Figure 3—Nisqually (A) and Orting (B) plots at 1- by 1-m spacing. Note the much greater success of establishment from Orting.

BEST COPY AVAILABLE

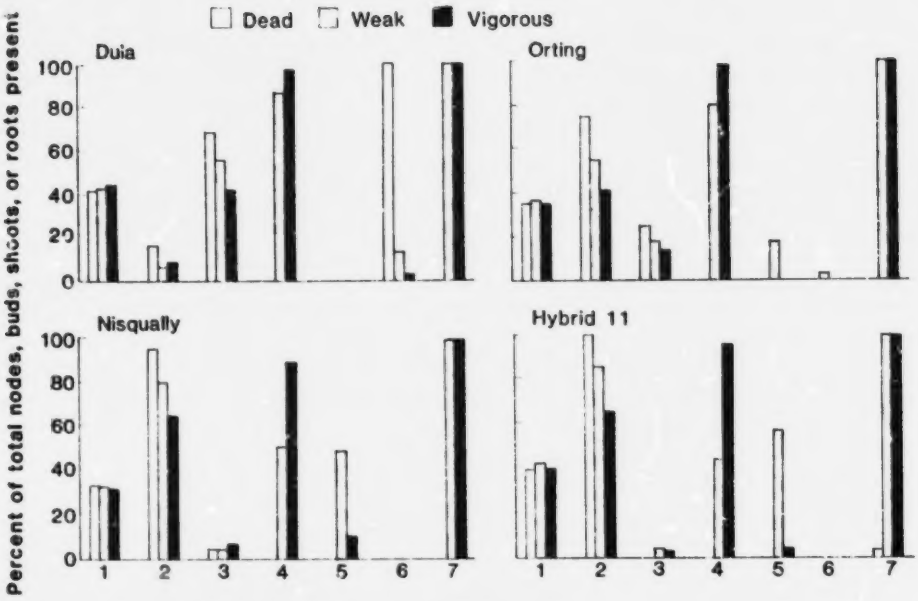

Figure 4—Selected characteristics of black cottonwood clones by cutting or plant category. 1 = nodes above ground, 2 = spent buds, 3 = dead buds, 4 = live nodal shoots, 5 = live internodal shoots, 6 = dead shoots, 7 = live roots.

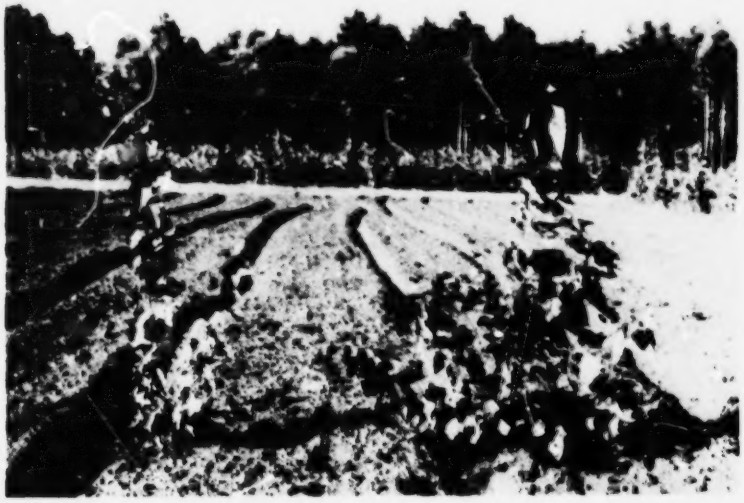

Figure 5—Dula (left) and Hybrid 11 (right) plants taken from the same spacing treatment. Note much more branching with Hybrid 11 than with Dula.

BEST COPY AVAILABLE

followup test established at our laboratory in spring 1986 showed that some shoots developed above ground on or near the base of the branch stubs of the spent buds. By the middle of the growing season, however, these shoots were weak and they were less than one-tenth the length of shoots that had developed from axillary buds of other cuttings.

Dead buds and shoots were most prevalent on the most successful clones (Dula and Orting) and least common on the least successful (Hybrid 11 and Nisqually). To some degree, the higher percentage of dead buds and shoots probably reflects more original axillary buds on cuttings of the more successful clones. Most dead buds and shoots were associated with the very thin cuttings, which were most common with Dula. Also, within clones, dead buds and shoots generally occurred in the order: dead cuttings > weak plants > vigorous plants.

All clones had considerably more live nodal shoots than live internodal shoots. Also, within clones, there were more nodal shoots on the vigorous plants than on the weak ones; the opposite was true for internodal shoots. For all clones, therefore, most shoots originated from axillary buds at the nodes. Live internodal shoots occurred mostly in Hybrid 11 and Nisqually (about 30 percent). Those two clones were also highest in spent buds, and success of their cuttings depended, to a large extent, on initiation and development of adventitious buds from the internodes, as explained above. The tendency for shoots to produce branches from axillary buds during the same year in which shoots develop on cuttings appears to be common among native deciduous angiosperms in the Pacific Northwest.

As expected, all successful cuttings had live roots, regardless of clone or plant vigor. In contrast, the two native *Populus* clones (Nisqually and Orting) had more live shoots per plant than did the two hybrid clones (Dula and Hybrid 11); the opposite was true for percentage of nodes above the ground. Apparently, these characteristics were not related to clonal differences in establishment success.

Conclusions

At present, the literature contains no specifications for cuttings of black cottonwood for maximum success of establishment. As with other *Populus* species (Hansen and others 1982), however, the importance of minimum length and diameter of cuttings and depth of planting has been recognized in some publications and in conventional practice. Our results indicate that establishment success and 1st-year growth will be greatest if cuttings also have healthy axillary buds. Cuttings, therefore, should not be made from the part of stems where maximum branching has occurred. Also, as with other species, cuttings should not be made from tip portions of shoots that are usually low in stored foods (Hartman and Kester 1983) and where axillary buds may not be fully developed. We believe establishment success from the recommended high-grade cuttings will be high and that the resulting experimental plantings will permit valid comparisons of productivity of different genotypes. Indeed, cuttings made using the recommended criteria resulted in establishment successes of nearly 100 percent for each of the four clones in our 1986 plantings. Furthermore, early growth is much more uniform and will thus provide a more sensitive test of differences among and within clones for cultural treatments such as fertilizing and spacing.

Acknowledgments This work was supported in part by a grant from the U.S. Department of Energy.

English Equivalents

1 millimeter (mm) = 0.039 inch
1 centimeter (cm) = 0.39 inch
1 kilogram (kg) = 2.2046 pounds
°C = (°F-32)/1.8

Literature Cited

Hansen, E.; Moore, L.; Netzer, D.; Ostry, M.; Phipps, H.; Zavitkovski, J. Establishing intensively cultured hybrid poplar plantations for fuel and fiber. Gen. Tech. Rep. NC-78. St. Paul, MN: U.S. Department of Agriculture, North Central Forest Experiment Station; **1982.** 24 p.

Hartman, H. T.; Kester, D. E. Plant propagation, principles and practices. Englewood Cliffs, NJ: Prentice-Hall, Inc.; **1983.** 727 p.

Heilman, P. E.; Stettler, R. F. Genetic variation and productivity of *Populus trichocarpa* and its hybrids. II. Biomass production in a 4-year plantation. Canadian Journal of Forest Research. 15: 384-388; **1985.**

Snedecor, G. W. Statistical methods applied to experiments in agriculture and biology. Ames, IA: Iowa State University Press; **1961.** 534 p.

Pacific Northwest Research Station
319 S.W. Pine St.
P.O. Box 3890
Portland, Oregon 97208

June 1987

☆ U.S. GOVERNMENT PRINTING OFFICE: 1987—794-190